Biomass gasification for CHP with dry gas cleaning and regenerative heat recovery

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Utilisation of biomass and waste is a sustainable and environmentally friendly way of energy production, which may contribute to the reduction of the greenhouse effect, utilise local resources and improve local employment. Small CHP plants will certainly constitute the most promising route, as they represent the major market perspective in terms of replication. Gasification is the most promising technology if the technical constraints to its spreading, cleaning of the producer gas, is solved.

In parallel, it has been demonstrated that the production costs of the gasification process consist of about two third of cost proportional to the investment cost. Going into detail with these costs it appears, that it if is possible to develop a process where biomass drying, gas scrubbing and wastewater treatment are unnecessary this technology will be the most competitive.

Objectives

The overall objective of this ongoing European project is to develop, integrate and prove a dry gas cleaning system on an existing biomass gasification combined heat and power plant (250 kWth). The innovative idea of this project is a newly developed dry gas cleaning and heat recovery system. The dry gas-cleaning concept produces no wastewater and, intends to solve and eliminate the tar problems associated with operation of biomass gasifiers by recirculating the tars back into the gasifier. The project includes the construction and test of the new gas-cleaning unit with an existing CHP gasifier for at least 500 hours. A study is carried out on the behaviour of tar under varying reactor and cooling conditions, and calculation of economical and environmental impact of the process will be made. These will clarify whether the new gas treatment device used in small CHP gasification unit will be beneficial in replacing conventional plant.

The scientific objectives of this project concern the set up and test of the gas cleaning system adapted to biomass gasification CHP plants and the tentative definition of standards of engine tolerance towards tar. The following technical objectives may be listed:

(i.) Design and construct two hot producer gas (700-800 ^{o}C) particulate cleaning systems, multicyclone and candle filter, which can operate continuously and achieve separation efficiency acceptable for engine applications.

(ii.) Design and construct a tar condensing, regenerative gas-gas heat exchanger able to provide a clean gas, which can operate continuously and achieve separation efficiency acceptable for engine applications. The amount of condensed tar depends on the gasifier design, but one heat exchanger cycle should not last less than 500 hours.

(iii.) Rebuild the carburettor and exhaust system on an existing gas engine in order to achieve emissions of CO below 500 ppm, hydrocarbons below 100 ppm and NO_x below 500 ppm. The biofuel (20 % moisture)-to-power efficiency should be at least 22 %. All performance data are well superior to the existing ones.

(iv.) Test the complete system including an existing downdraft wood chip fired gasifier of 250-kWth capacity, dust separator, regenerative heat exchanger and engine-generator for at least a ½ regenerative cycle (250 hours).

(v.) Study tar characteristics and tar behaviour under varying reactor and cooling conditions with special attention to engine quality.

The industrial objective is to develop a small and medium size CHP unit that can be constructed locally to a competitive price and run with very low emissions and good efficiency utilising local bio-fuels.

The social and economic objectives of the project are clearly to enhance both the quality of life of the European citizen and the competitiveness of European industry in world markets. By developing this new efficient and clean energy production technology, the success of the project will contribute to achieve the following objectives in accordance with the EU policies:

(i.) Increase the competitiveness of European industry in the world market, not only for industrialised countries, but also for the huge potential market, which is located in developing countries like China or India.

(ii.) Increase the employment rate in EU by creation of new activities based on development of small and medium gasification plants, the production, distribution and handling of fuels, and the maintenance of CHP plants, etc.

(iii.) Contribute to the rural development by supporting potential agricultural and forestall fuels issued of forestry, forest industries, secondary wood industry, olive production, nut production and agriculture.

(iv.) Contribute to decrease the greenhouse effect by substitution of fossil fuels with a sustainable and renewable energy source.

(v.) Increase the EU fuel independency.

Result and conclusion

The project has been focused on the design and the construction of the complete gas-cleaning unit, which is the key part of the process. The gas-cleaning unit is divided in a hot producer gas (700-800°C) particulate cleaning system, and a tar elimination system. Two new technologies have been selected for the high temperature particulate cleaning step: multicyclone technology and high temperature ceramic candle filter technology. A new generation of small scale tar condensing, regenerative gas-gas heat exchanger able to provide a clean gas free from tars creating problems in an engine has been designed and constructed. The heat exchanger allows both condensation of tar and thermal cracking with heat recovery. This principle should operate continuously and achieve separation efficiency acceptable for engine applications, preferably without further particulate removal. The complete gas-cleaning unit is on going connection with the existing downdraft wood chip fired gasifier of 250-kWth and an engine-generator.

Market evaluation

The total market potential in EU for the coming decade is considered to be about 7 000 MWth for biomass fired CHP units up to 20 MWth. It does not seem unrealistic that down draft gasification technology makes up 10% of this capacity, if technical and economical limitations are solved.